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1 Indirect radiative forcing of climate change through ozone effects on the land-carbon sink

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The evolution of the Earth's climate over the 21^{st} century depends on the rate at which anthropogenic CO_2 emissions are removed from the atmosphere by the ocean and land carbon cycles. Coupled climate-carbon cycle models suggest that global warming will act to limit the land carbon sink, but these first generation models neglected the impacts of changing atmospheric chemistry. Tropospheric ozone is known to damage plants, reducing plant primary productivity and crop yields. Emissions associated with fossil fuel and biomass burning have acted to approximately double the global mean tropospheric ozone concentration, and further increases are expected over the 21^{st} century. Here we estimate the impact of these projected changes in ozone on the land-carbon sink, using a global land carbon cycle model modified to include the effect of ozone deposition on photosynthesis and to account for interactions between ozone

and CO_2 through stomatal closure. For a range of sensitivity parameters based on manipulative field experiments, we find a significant suppression of the global land carbon sink as increases in ozone negatively affect plant productivity. The additional CO_2 that is left in the atmosphere constitutes an indirect radiative forcing through ozone effects on plants, that could exceed global warming due to the direct radiative effect of tropospheric ozone increases.